Biological Assessment Report

Joachim Creek

Jefferson County, Missouri

Fall 2020 and Spring 2021

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

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1.0 Introduction

At the request of the Missouri Department of Natural Resources' (**MoDNR**) Water Protection Program (**WPP**), the Environmental Services Program's (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate biological assessment and habitat study of Joachim Creek during the fall of 2020 and spring of 2021. Fall sampling occurred on September 15-16, 2020, and consisted of macroinvertebrate sampling, stream habitat assessments, water quality, and sediment sampling. Spring sampling was conducted on April 6-7, 2021. A habitat assessment of Saline Creek, a biological criteria reference stream (**BIOREF**) in Ste. Genevieve County, Missouri, was conducted on September 16, 2020, to compare with Joachim Creek. Sampling was completed by Brandy Bergthold and Rory Mott.

The assessed reach of Joachim Creek is in Jefferson County, Missouri. It is categorized as a warm water class P stream (i.e. a stream that maintains permanent flow even in drought periods) with a Water Body Identification (**WBID**) number of 1719. Joachim Creek originates in northern St. Francois County, flows through Jefferson County, and empties into the Mississippi River at Herculaneum, Missouri. Joachim Creek WBID 1719 has the following designated uses based on the 2018 Missouri Water Quality Standards (**WQS**; MoDNR 2018f): human health protection, industrial water supply, irrigation, livestock and wildlife protection, secondary contact recreation, warm water habitat, and whole body contact recreation Category A.

The Joachim Creek watershed has numerous permitted outfalls that may influence stream water quality and aquatic life. Joachim Creek travels through municipalities including De Soto, Festus, and Herculaneum before discharging into the Mississippi River. Both the De Soto Waste Water Treatment Plant (**WWTP**; Permit #MO0026662) and the Herculaneum WWTP (Permit #MO0027111) have permitted outfalls emptying into Joachim Creek. Moreover, the city of De Soto is known to have severe flooding (Heimann et al. 2018), which may increase non-point source inputs into the stream (Carle et al. 2005).

Several present and historical heavy metal mining operations are located throughout the watershed. The downstream portion of Joachim Creek is near Herculaneum's historic lead smelter. From 1892 to 2013, the Herculaneum smelter processed lead and other heavy metals and adversely affected the surrounding soils and wetlands (USFWS and MoDNR 2019). Remediation efforts included soil replacement on residential properties and implementation of environmental controls expressed by current laws.

1.1 Study Area

Joachim Creek is located in the Ozark/Apple/Joachim Ecological Drainage Unit (**EDU**). An EDU is a region that contains similar biological communities and habitat conditions. Joachim Creek was assessed for this study using biological criteria calculated from wadeable/perennial biological criteria reference (**BIOREF**) streams in the EDU (Figure 1). Closely positioned to the Southeast Missouri Lead District (Kleeschulte 2008), the Joachim Creek watershed contains numerous historical and current mines (Figure 2). These mines are most concentrated in the Festus, Missouri, area and the upstream portion of Joachim Creek (Figure 2). The watershed was also the location of remediation efforts in regards to the historic smelter in Herculaneum (USFWS and MoDNR 2019).

Figure 1: Locations of Study Stream within the Ozark/Apple/Joachim EDU

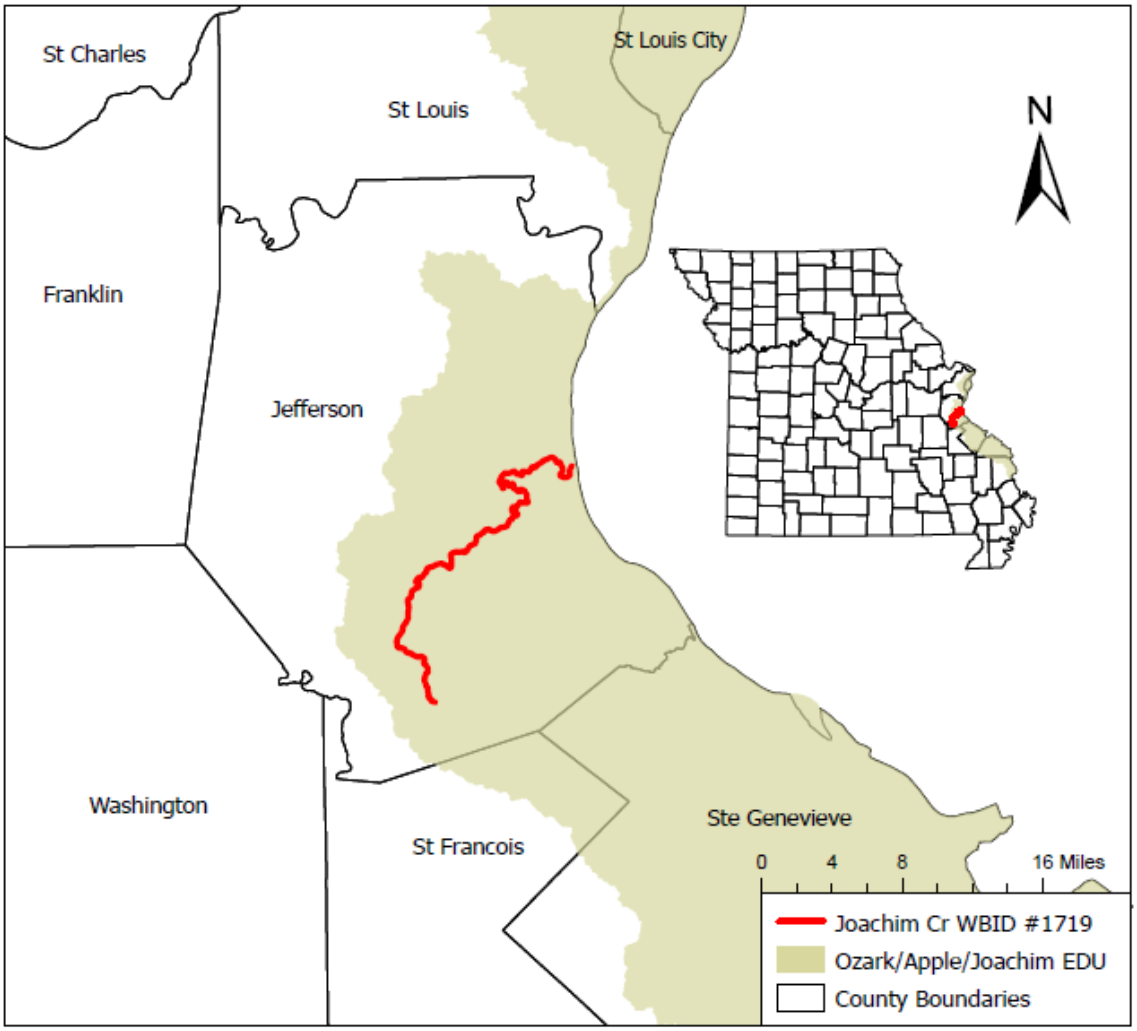
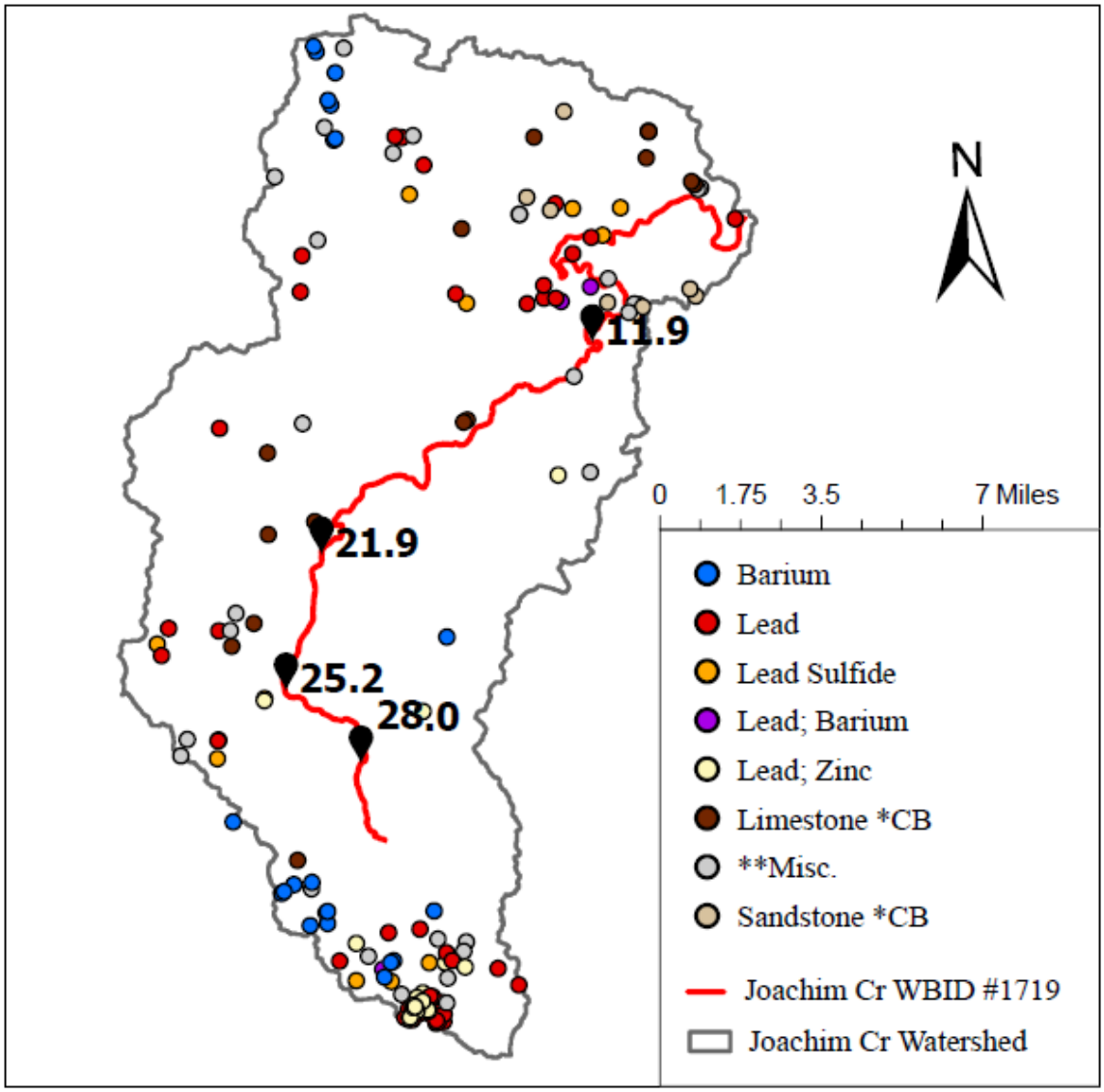


Figure 2: Historical and current mines located in Joachim Creek Watershed

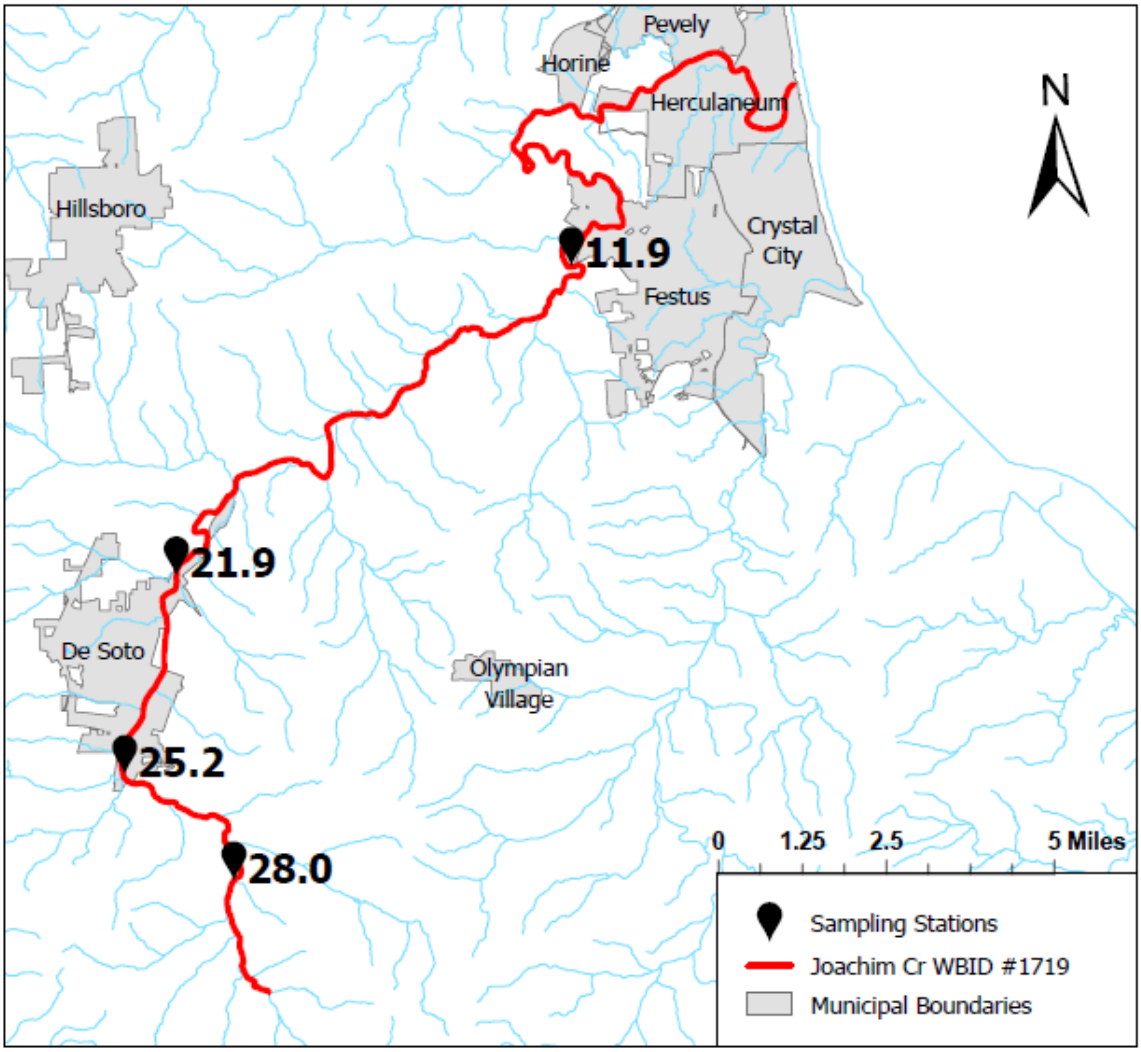


* CB - Crushed and/or broken; ** Miscellaneous mines include various combinations of barium, copper, copper sulfide, iron limonite, iron pyrite, iron sulfide, lead, lead carbonate, lead sulfide, limestone, limestone chert bed, sand and gravel, sandstone, sandstone chert bed, silica, silica foundry sand, silica sandstone, silver, zinc, zinc carbonate, zinc sulfide, or an undescribed resource.

1.2 Station Descriptions

Four stations were sampled on Joachim Creek, all of which were in Jefferson County. Station numbers are derived from the distance upstream (in river miles) from the WBID termination point. The following locations and descriptions correspond with the station labels in Figure 3.

Figure 3: Joachim Creek Stations with Surrounding Municipalities



Joachim Creek Station 1719/11.9 was sampled adjacent to West Main Street, just west of the Festus city limits. UTM Zone 15 coordinates at the midpoint of the sample reach are E724523, N4233681. The legal description is S1/2 SUR 00391, T. 40 N., R. 05 E.

Joachim Creek Station 1719/21.9 was sampled downstream of the State Highway 110 bridge and upstream of the De Soto WWTP outfall. UTM Zone 15 coordinates at the upstream boundary of the sample reach are E715068, N4226273. The legal description is N1/2 SUR 02008, T. 40 N., R. 04 E.

Joachim Creek Station 1719/25.2 was sampled upstream of the State Highway E bridge. UTM Zone 15 coordinates at the upstream boundary of the sample reach are E713831, N4221519. The legal description is NW1/4 sec. 11, T. 39 N., R. 04 E.

Joachim Creek Station 1719/28.0 was sampled upstream of the Hammon Farm Road bridge. UTM Zone 15 coordinates at the upstream boundary of the sample reach are E716447, N4218973. The legal description is SE1/4 sec. 13, T. 39 N., R. 04 E.

2.0 Methods

Macroinvertebrate and water quality sampling was conducted during fall 2020 and spring 2021 by WQMS's Aquatic Bioassessment Unit.

Methods for stream habitat assessments, biological assessments, dissolved metals, physicochemical water quality, and sediment sample collection are included in this section. All samples were handled according to the appropriate MoDNR ESP Standard Operating Procedures (**SOP**) and Project Procedures (**PP**).

2.1 Stream Habitat

Stream habitat is a foundational filter for aquatic communities and as such determines which species can be supported. Stream habitat was assessed using procedures for riffle/pool streams in the *Stream Habitat Assessment Project Procedure* (**SHAPP**, MoDNR 2019i). The total habitat score equaled the sum of scores for each of 10 habitat measures assessed along 10 separate sections of the stream reach. A stream reach was defined as 20 times the average width of the stream. Joachim Creek habitat scores were compared to those of Saline Creek, a BIOREF site. Study stream habitat scores that were ≥75 percent of the BIOREF habitat score indicated these habitats should be able to support biological communities comparable to the reference stream (MoDNR 2019i).

2.2 Stream Physicochemistry

Physicochemical water samples collected in fall 2020 and spring 2021 were handled according to the appropriate MoDNR ESP SOPs. Results for physicochemical water parameters were examined by season and station using *in situ* field measurements or grab samples collected in accordance with the SOP MDNR-ESP-001, *Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2019c). All samples were kept on ice during transport to ESP.

Water quality field parameters were measured *in situ* and water quality samples were collected and returned for analyses at the ESP laboratory in Jefferson City. Turbidity (NTU, MoDNR 2018b) was measured in the ESP, WQMS biology laboratory. Discharge (cubic feet per second-**cfs**, MoDNR 2019e), DO (mg/L, MoDNR 2019d), conductivity (µS/cm, MoDNR 2018e), pH (standard units, MoDNR 2018c), and temperature (°C, MoDNR 2018d), were measured in the field. The ESP Chemical Analysis Section conducted analyses for the following: nitrate plus nitrite-nitrogen, total nitrogen, total phosphorus, ammonia as N, sulfate, chloride, total suspended solids/non-filterable reside, dissolved calcium, and dissolved magnesium (all parameters reported in mg/L). Physicochemical water parameters were compared among stations as well as with Missouri's WQS (MoDNR 2018f). Nutrient values were compared to U.S. EPA's recommended nutrient values for rivers and streams in nutrient ecoregion XI (USEPA 2000). Dissolved metals concentrations were compared to hardness-dependent WQS. Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and beneficial uses as designated in the WQS (MoDNR 2018f).

2.3 Fine Sediment

In fall 2020, benthic fine sediment composite samples were collected instream from Joachim Creek stations, processed according to MDNR-ESP-011 *General Sampling Considerations for Chemical Analysis of Sediments* (MoDNR 2018a), and analyzed for total recoverable metals content (As, Cd, Co, Cu, Pb, Ni, and Zn).

Individual metals concentrations were compared to Probable Effects Concentrations (**PEC**s; MacDonald et al. 2000). A PEC is a threshold level for a contaminant, above which harmful effects are likely to be observed in a freshwater ecosystem. The PEC for arsenic = 33.0 mg/kg, cadmium = 4.98 mg/kg, chromium = 111 mg/kg, copper = 149 mg/kg, lead = 128 mg/kg, nickel = 48.6 mg/kg, and zinc = 459 mg/kg (MacDonald et al. 2000).

Individual metals were also examined using a Probable Effects Concentration Quotient (**PEQ**, MacDonald et al. 2000, 2009; Ingersoll et al. 2001; Besser et al. 2015). A PEQ is the total recoverable metal concentration divided by the PEC threshold for that metal (MacDonald et al. 2000). A PEQ greater than 1.0 may indicate an increased risk of toxicity due to the concentration of that metal (Ingersoll et al. 2001, Besser et al. 2015).

Individual metals concentrations were compared to the Tri-State Mining District (**TSMD**) site specific thresholds (**T_{10}**) to further assess the potential risk of toxicity to benthic invertebrates (MacDonald et al. 2009). A level above a T_{10} value corresponds to a 10 percent reduction in the control-adjusted survival or biomass of amphipods, midges, or mussels compared to the average response rate for toxicity test organisms exposed to reference sediments. The T_{10} for cadmium = 11.1 mg/kg, lead T_{10} = 150 mg/kg, and zinc T_{10} = 2083 mg/kg.

The cumulative toxic effects from compounding metals contaminants may be examined using the sum of PEQs for cadmium, lead, and zinc ($\sum$**PEQ$_{Cd, Pb, Zn}$**, Ingersoll et al. 2001, MacDonald et al. 2000, 2009) or the mean PEQ for all metals (**mean PEQ$_{metals}$**). The mean PEQ$_{metals}$ is suggested to normalize sample results and excludes cobalt, for which no PEQ currently exists (MacDonald et al. 2000, 2009, Ingersoll et al. 2009, Besser et al. 2009). Although the $\sum$PEQ and the mean PEQ are included for comparison, both are individually effective in predicting potential toxicity due to a mixture or combination of metals. The T_{10} used for $\sum PEQ_{Cd, Pb, Zn} = 7.92$ and the mean $PEQ_{metals} = 1.11$ (MacDonald et al. 2009). Quotients above these thresholds suggest the mixture or combination of metals associated with fine sediment may be potentially toxic to the benthic-dwelling macroinvertebrate community.

2.4 Bioassessment

Macroinvertebrate sampling was conducted according to the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (**SMSBPP**, MoDNR 2019b). Joachim Creek is considered a riffle/pool dominated system. The three standard habitats sampled at all locations were flowing water over coarse substrate (**CS**), non-flowing water over depositional substrate (**NF**), and submerged rootmat (**RM**). Macroinvertebrate samples were subsampled in the laboratory and identified to taxonomic levels as specified in MoDNR's *Taxonomic Levels for Macroinvertebrate Identifications* SOP (MoDNR 2019f) to develop biological metrics (MoDNR 2019b). Macroinvertebrate bench sheet data are included in Appendix A.

Joachim Creek macroinvertebrate data were evaluated relative to biological criteria calculated using samples collected from BIOREF streams in the Ozark/Apple/Joachim EDU (Appendix B). Biological criteria are calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The four components of the MSCI are Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered fully supporting, 10-14 partially supporting, and 4-8 is non-supporting of the protection of warm water aquatic habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2018f).

2.5 Quality Assurance/Quality Control (QA/QC) of Bioassessment Data

2.5.1 Data Collection

Data were collected following guidelines in *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019g).

2.5.2 Meter Calibration

Field meters used to record temperature, dissolved oxygen, pH, and specific conductance were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016).

2.5.3 Macroinvertebrate Subsampling

Macroinvertebrates from collected samples were checked for accuracy using methods in the SMSBPP (MoDNR 2019b).

2.5.4 Macroinvertebrate Data Entry

Macroinvertebrate data were entered into the WQMS macroinvertebrate database in accordance with *Quality Control Procedures for Data Processing* (MoDNR 2019h).

2.5.5 Duplicate Sample Collection

Duplicate samples are obtained from the same location and time as the true sample following the same procedures in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019g). True samples and duplicate samples are analyzed for the same set of parameters. A duplicate is used to assess the precision associated with sampling methodology, sample heterogeneity, and analytical procedures (MoDNR 2019g). Duplicate physicochemical and macroinvertebrate samples were collected at station 21.9 in spring 2021.

3.0 Bioassessment Results

3.1 Land Use

Overall land use of the Joachim Creek drainage is shown in Figure 4. Table 1 includes the land use percentages of Joachim Creek station drainages, the SHAPP control station, and the Ozark/Apple/Joachim EDU. These data are derived from 2019 National Land Cover Database (**NLCD**) imaging (Dewitz 2021). All stations, including the SHAPP control station, are dominated by deciduous forest and hay/pasture. There are many urban developed areas immediately surrounding the three lower sampling stations. However, the total percent of developed land use is relatively low compared to the percent of deciduous forest and hay/pasture land use (Table 1).

Figure 4: 2019 NLDC Land Use of the Joachim Creek Watershed

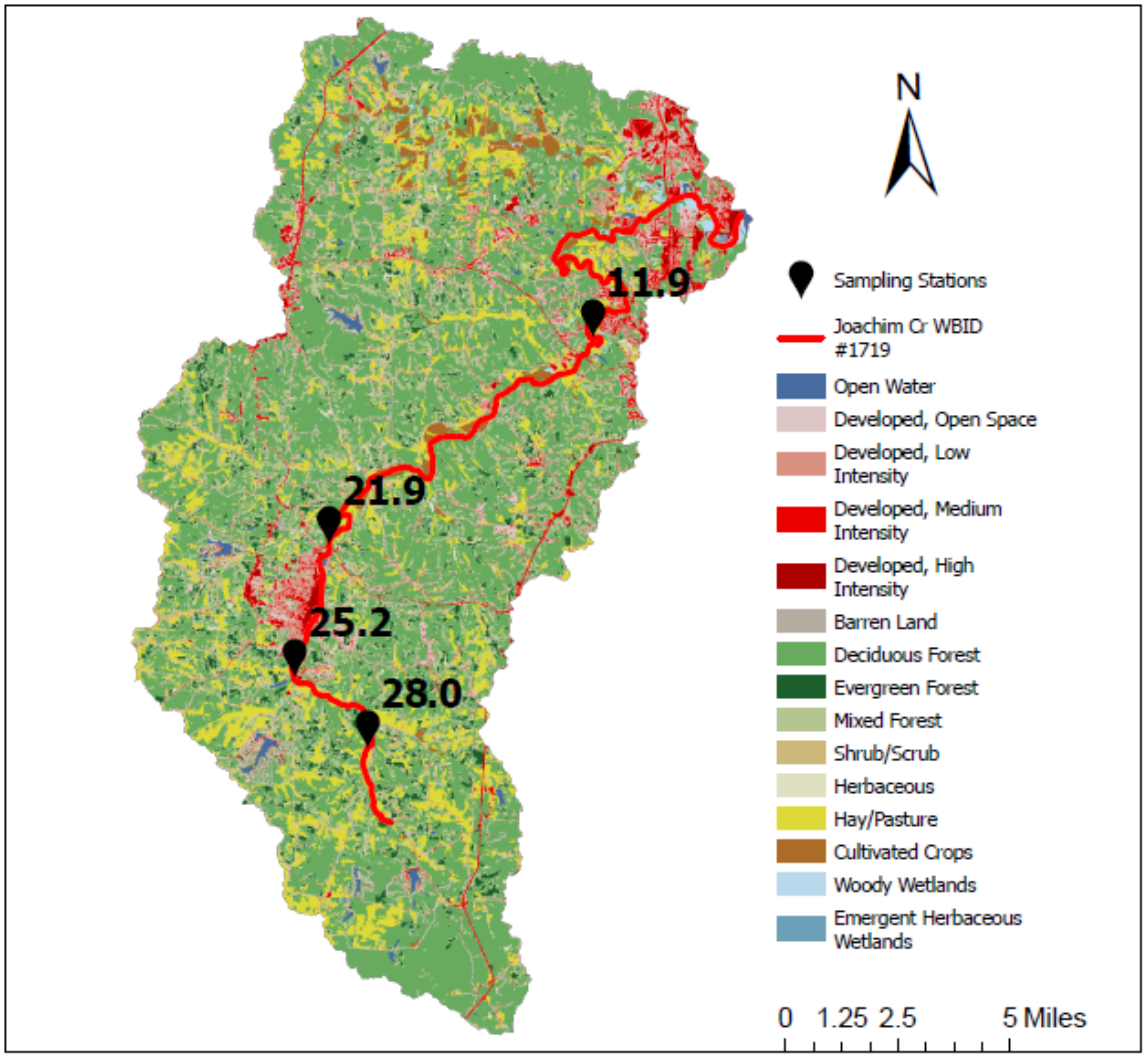


Table 1: Percent Land Use of Joachim Creek Sampling Stations, the Saline Creek BIOREF Station, and the Ozark/Apple/Joachim EDU

Stream Habitat Parameters	Joachim Cr 1719/11.9	Joachim Cr 1719/21.9	Joachim Cr 1719/25.2	Joachim Cr 1719/28.0	Saline Cr BIOREF	Ozark/Apple/ Joachim EDU
Open Water	0.67	0.96	1.15	0.97	0.27	2.42
Developed, Open Space	6.19	6.36	5.34	4.69	4.99	4.70
Developed, Low Intensity	4.75	5.09	2.92	2.32	1.46	7.67
Developed, Medium Intensity	1.75	1.89	1.00	0.89	0.71	4.76
Developed, High Intensity	0.38	0.54	0.08	0.05	0.17	2.16
Barren Land	0.12	0.07	0.05	0.06	0.05	0.42
Deciduous Forest	50.60	48.12	51.30	59.10	61.41	40.85
Evergreen Forest	4.42	5.22	5.31	4.67	1.13	1.46
Mixed Forest	14.99	13.41	12.51	9.63	4.67	4.79
Shrub/Scrub	0.55	0.46	0.48	0.50	0.32	0.28
Herbaceous	0.77	0.69	0.56	0.51	0.36	0.43
Hay/Pasture	13.90	16.83	18.90	16.31	23.79	17.79
Cultivated Crops	0.61	0.19	0.24	0.18	0.36	11.01
Woody Wetlands	0.27	0.15	0.16	0.13	0.28	1.12
Emergent Herbaceous Wetland	0.04	0.02	0.02	0.00	0.04	0.15

3.2 Stream Habitat

Habitat assessment scoring results are found in Table 2. If the study station SHAPP score is ≥75 percent of the control station score, it is considered to have habitat comparable to the control station (MoDNR 2019i). Comparable habitats should support similar biological communities. All stations but Joachim Creek 11.9 scored ≥75 percent of the habitat reference stream SHAPP score.

With the exception of station 11.9, Joachim Creek had good substrate with abundant cobble for epifaunal substrate. Riffle quality and velocity/depth regime scored well in the three upstream stations. Station 25.2 scored slightly lower on channel alteration, bank stability, and vegetative protection due to its urban location at Walther Park in De Soto, Missouri (Table 2). Joachim Creek station 11.9 was considered not comparable to the SHAPP control because it scored <75 percent of the habitat reference stream SHAPP score. Sediment deposition in the station 11.9 sample reach affected riffle quality and epifaunal substrate, which contributed to the overall lower score.

Table 2: Stream Habitat Assessment Results for Joachim Creek Study Sites and the Saline Creek BIOREF Site

Stream Habitat Parameters	**Joachim Cr 11.9**	**Joachim Cr 21.9**	**Joachim Cr 25.2**	**Joachim Cr 28.0**	**Saline Cr BIOREF**
Habitat Assessment Date	9/15/2020	9/15/2020	9/16/2020	9/16/2020	9/16/2020
Epifaunal Substrate/Available Cover	8	16	16	17	13
Embeddedness	11	13	16	12	18
Velocity/Depth Regime	10	15	10	14	15
Sediment Deposition	3	10	15	13	5
Channel Flow Status	11	16	18	14	13
Channel Alteration	13	18	10	16	20
Riffle Quality	8	15	13	18	17
Left Bank Stability	9	7	9	10	10
Right Bank Stability	10	10	9	10	10
Left Bank Vegetative Protection	0	2	3	6	1
Right Bank Vegetative Protection	0	4	5	3	1
Left Bank Riparian Zone Width	10	9	10	10	10
Right Bank Riparian Zone Width	9	7	3	4	5
Total Habitat Score	**102**	**142**	**137**	**147**	**138**
Percent of BIOREF Score	**73.9**	**102.9**	**99.3**	**106.5**	**-**

3.3 Physicochemical Analysis and Fine Sediment

Discharge, *in situ* water quality results, and dissolved metals analysis for Joachim Creek stations are presented in Table 3 and Table 4. No WQS violations occurred during either field season (MoDNR 2018f).

Currently, no nutrient criteria are in place for Missouri streams and rivers, so Joachim Creek nutrients and turbidity were compared to the U.S. EPA's *Ambient Water Quality Criteria Recommendations for Rivers and Streams in Nutrient Ecoregion XI* (USEPA 2000). Joachim Creek study stations are located in the Ozark Highlands Level III ecoregion. Recommended nutrient values for the Ozark Highlands (i.e. level III ecoregion 39) are 0.239 mg/L nitrate plus nitrite-nitrogen, 0.379 mg/L total nitrogen, 0.007 mg/L (rounded from 6.625 µg/L) total phosphorus, and 1.425 NTU turbidity (USEPA 2000). These values are merely recommendations to establish water quality criteria and are not regulations themselves.

In fall 2020, Joachim Creek station 11.9 exceeded EPA's recommended value for nitrate plus nitrite-nitrogen, total nitrogen, and turbidity (Table 3). All Joachim Creek stations exceeded the recommended value for total phosphorus in fall 2020 (Table 3). In spring 2021, Joachim Creek station 11.9 exceeded EPA's recommend value for nitrate plus nitrite-nitrogen and total nitrogen (Table 4). All stations in spring 2021 exceeded total phosphorus and turbidity EPA recommended values (Table 4).

Sediment samples were collected from all Joachim Creek stations on November 17, 2020 (Table 5). All metals concentrations were below their respective PEC threshold values given by MacDonald et al. (2000) and were below the 150 percent PEQ limit described in the MoDNR 303(d) Listing Methodology Document (MoDNR 2019a). Furthermore, metals at all stations were below the $\sum PEQ_{Cd, Pb, Zn}$ threshold (Ingersoll et al. 2001) and the TSMD mean PEQs of all metals (MacDonald et al. 2009, Table 5).

Table 3: Joachim Creek Fall 2020 Discharge, *In Situ* Water Quality Measurements, and Physicochemical Results

	JC 11.9	JC 21.9	JC 25.2	JC 28.0
Collection Date	9/15/2020	9/15/2020	9/15/2020	9/16/2020
In situ Field Measurements				
Flow (cfs)	10.9	8.15	4.27	2.53
Temperature (°C)	21.1	22.1	23.2	19.3
Dissolved Oxygen (mg/L)	7.56	10.04	12.46	9.58
Conductivity (µS/cm)	570	535	469	510
pH (standard units)	8.04	8.25	8.65	8.21
Turbidity (NTU)	**8.08**	1.08	1.30	1.18
Lab Analysis				
Ammonia (mg/L)	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND
Nitrite+Nitrate (mg/L)	**0.271**	0.020	0.014	0.074
Total Nitrogen (mg/L)	**0.47**	0.20	0.19	0.23
Total Phosphorus (mg/L)	**0.06**	**0.012**	**0.032**	**0.022**
TSS (mg/L)	8.00	<5 ND	<5 ND	<5 ND
Chloride (mg/L)	26.5	21.7	17.2	15.3
Hardness (mg/L)	278	272	243	267
Sulfate (mg/L)	29.3	25.7	21.4	20.1
Dissolved Metals Analysis				
Calcium (mg/L)	54.3	49.8	42.3	46.7
Magnesium (mg/L)	34.6	35.8	33.4	36.5
Iron (µg/L)	5.54 08	9.16 08	3.00 05, 08	2.82 05, 08
Arsenic (µg/L)	0.80 05	0.56 05	0.75 05	0.82 05
Barium (µg/L)	179	204	198	303
Cadmium (µg/L)	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND
Cobalt (µg/L)	<1 ND	<1 ND	<1 ND	<1 ND
Copper (µg/L)	0.63 05	<0.5 ND	<0.5 ND	<0.5 ND
Lead (µg/L)	0.76 05	<0.5 ND	<0.5 ND	<0.5 ND
Manganese (µg/L)	30.8	11.1	3.89	6.00
Nickel (µg/L)	0.59 05	<0.5 ND	<0.5 ND	<0.5 ND
Zinc (µg/L)	2.18	5.95	2.38	11.0

Qualifiers are: ND - Not detected at reported value; 05 – Estimated value, detected below laboratory practical quantitation limits (**PQL**); 08 - Analyte present in blank at >1/2 reported value. Bold values are those that exceed EPA's recommended values.

Table 4: Joachim Creek Spring 2021 Discharge, *In Situ* Water Quality Measurements, and Physicochemical Results

	JC 11.9	JC 21.9	JC 21.9 (Duplicate)	JC 25.2	JC 28.0
Collection Date	4/06/2021	4/06/2021	4/06/2021	4/06/2021	4/07/2021
In situ Field Measurements					
Flow (cfs)	42.3	22.8	22.4	13.7	9.94
Temperature (˚C)	16.2	17.5	17.5	20.0	15.6
Dissolved Oxygen (mg/L)	9.85	10.97	10.97	13.96	9.28
Conductivity (µS/cm)	510	414	422	418	433
pH (standard units)	7.97	8.24	8.24	8.58	7.98
Turbidity (NTU)	**3.83**	**1.83**	**1.47**	**2.37**	**1.60**
Lab Analysis					
Ammonia (mg/L)	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND
Nitrite+Nitrate (mg/L)	**0.233**	0.051	0.069	0.035	0.100
Total Nitrogen (mg/L)	**0.37**	0.23	0.22	0.18	0.25
Total Phosphorus (mg/L)	**0.007 08**	**0.082**	**0.081**	**0.031 08**	**0.079**
TSS (mg/L)	7	<5 ND	<5 ND	<5 ND	<5 ND
Chloride (mg/L)	24.3	21.0	21.0	14.8	13.4
Hardness (mg/L)	255	246	248	228	231
Sulfate (mg/L)	26.8	22.9	23.2	20.0	17.2
Dissolved Metals Analysis					
Calcium (mg/L)	50.0	48.6	48.6	43.8	45.1
Magnesium (mg/L)	31.6	30.6	30.6	28.9	28.8
Iron (µg/L)	4.33 05	6.04	5.63	7.26	6.45
Arsenic (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	0.53 ND	0.53 05
Barium (µg/L)	142	188	185	193	252
Cadmium (µg/L)	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND
Cobalt (µg/L)	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND
Copper (µg/L)	0.91 05	0.90 05	0.85 05	0.79 05	0.70 05
Lead (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Manganese (µg/L)	35.1	11.4	11.1	11.1	9.50
Nickel (µg/L)	1.32	1.20	1.25	1.13	1.15
Zinc (µg/L)	3.83	18.0	17.6	11.4	44.3

Qualifiers are: ND - Not detected at reported value; 05 - Estimated value, detected below PQL; 08 - Analyte present in blank at >1/2 reported value. Bold values are those that exceed EPA's recommended values.

Table 5: Sediment Sample Results for Joachim Creek Collected on November 17, 2020

	JC 11.9	JC 21.9	JC 25.2	JC 28.0	PEC Threshold	PEQ Threshold
Arsenic (mg/kg) (PEQ)	2.34 [05] (0.071)	5.17 (0.157)	5.69 (0.172)	5.15 (0.156)	33.0	>1.0
Cadmium (mg/kg) (PEQ)	<0.1 [ND] (NA)	0.262 [05] (NA)	0.366 [05] (NA)	0.811 (0.163)	4.98	>1.0
Chromium (mg/kg) (PEQ)	9.70 (0.087)	21.1 (0.190)	19.5 (0.177)	17.6 (0.159)	111	>1.0
Copper (mg/kg) (PEQ)	5.54 [06] (0.037)	7.19 (0.048)	4.04 (0.027)	4.49 (0.030)	149	>1.0
Lead (mg/kg) (PEQ)	14.9 [06] (0.116)	37.2 (0.291)	31.8 (0.248)	90.1 (0.704)	128	>1.0
Nickel (mg/kg) (PEQ)	3.28 (0.067)	6.35 (0.131)	5.41 (0.111)	4.94 (0.102)	48.6	>1.0
Zinc (mg/kg) (PEQ)	129 (0.281)	163 (0.355)	192 (0.418)	13.6 [09] (0.030)	459	>1.0
$\sum PEQ_{Cd,Pb,Zn}$	0.397	0.646	0.666	0.897	-	≥7.92
Mean PEQ_{metals}	0.094	0.167	0.281	0.192	-	T_{10}≥1.11
% Moisture by Infrared Drying	21.4	21.1	21.6	18.8	-	-
% Moisture by Contract Lab	22.2	24.5	23.4	21.8	-	-
Total Organic Carbon by Contract Lab (mg/kg)	<775 [ND]	2330	4810	2050	-	-

Probable Effects Concentration (PEC) from MacDonald et al. (2000); Toxicity threshold (T_{10}) mean of all metal's Probable Effect Concentrations Quotient (PEQ) from MacDonald et al. (2009). Qualifiers are: ND - not detected at reported value; 05 - Estimated value, detected below PQL; 06 - Estimated value, QC data outside limits; 09 - Sample diluted during analysis.

3.4 Biological Assessment

3.4.1 Macroinvertebrate Community Composition

In all fall 2020 samples, Ephemeroptera accounted for over 30 percent of invertebrates at each site (Table 6). Prominent Ephemeroptera families included Baetidae, Caenidae, Heptageniidae, and Leptohyphidae (Table 6). The mayfly genera *Baetis* (BI = 6.0) and *Tricorythodes* (BI = 5.4) were highly abundant in all fall 2020 samples. *Caenis* species were plentiful in all stations with more *C. anceps* (BI = 7.6) occurring in downstream stations and *C. latipennis* (BI = 7.6) in upstream stations. There were almost no Plecoptera found among sample sites (Table 6). Trichoptera were found in the highest abundance at the most downstream station (Table 6). *Cheumatopsyche* (BI = 6.6) was the dominant caddisfly at Station 11.9, but the upper stations had high sample densities of *Helicopsyche* (BI = 0). Chironomidae accounted for 8.79 percent of the Joachim Creek station 28.0 sample and increased successional downstream to Joachim Creek station 11.9, where chironomids made up 39.27 percent of the sample (Table 6).

Fall 2020 functional feeding groups (**FFG**) were primarily composed of filterer collectors, gatherer collectors, and scrapers (Figure 5). Filterer collectors and scrapers differed noticeably among Joachim Creek stations, depending on the proximity to the Mississippi River. The percentage of filterer collectors in samples dramatically decreased from downstream to upstream. Filterer collectors decreased from 29.58 percent at Joachim Creek station 11.9 to 11.38 percent at Joachim Creek station 28.0. The inverse relationship can be seen with scrapers, which increased from 11.95 percent at station 11.9 to 41.74 percent at station 28.0.

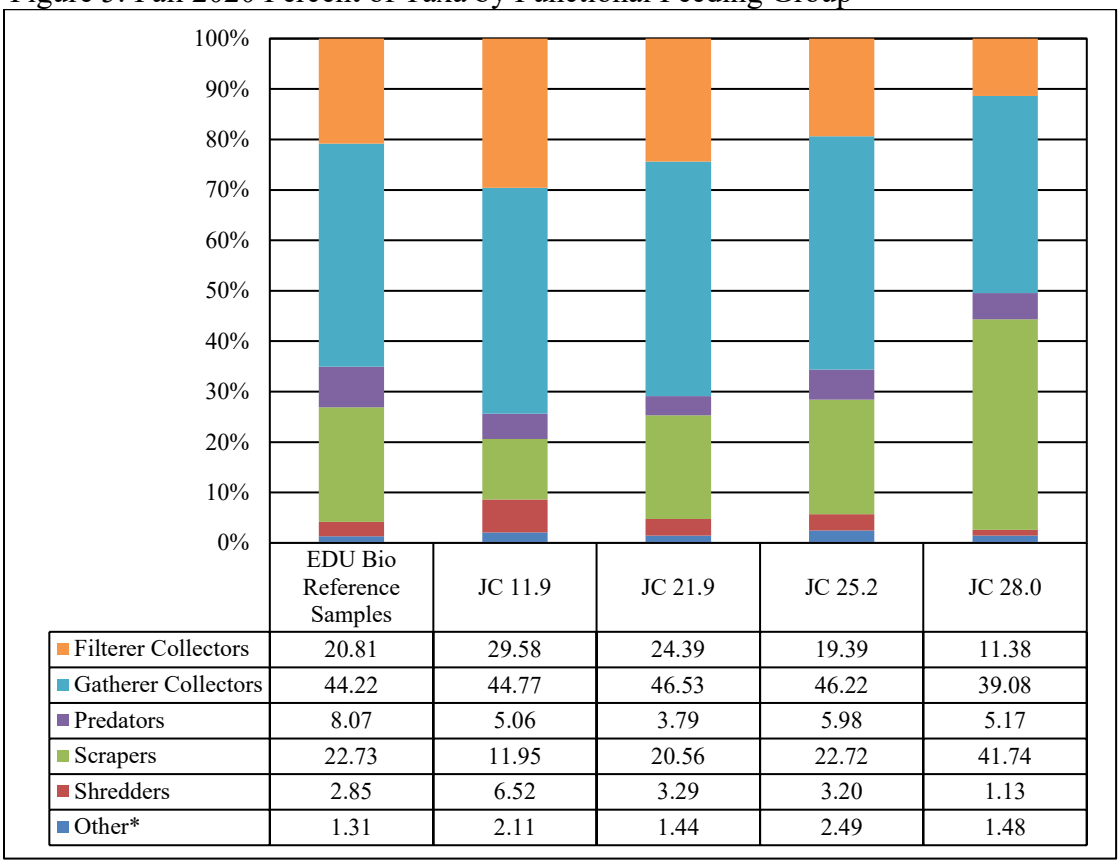
During fall 2020, Joachim Creek contained mostly moderately tolerant (BI 5.0 - 7.4) invertebrates in each sample (Figure 6). Station 28.0, the most upstream station, had the highest percentage of intolerant invertebrate taxa (34.5 percent). Stations 25.2 and 28.0 had the greatest percentage of very intolerant (BI < 2.5) taxa.

Table 6: Fall 2020 Joachim Creek Riffle/Pool Macroinvertebrate Composition

	JC 11.9	JC 21.9	JC 25.2	JC 28.0
Collection Date	9/15/2020	9/15/2020	9/15/2020	9/16/2020
Taxa Richness	77	75	87	90
Number EPT Taxa	22	21	22	25
% Ephemeroptera	30.21	36.02	35.71	34.12
% Plecoptera	0.0	0.0	0.27	0.0
% Trichoptera	12.38	6.97	8.79	7.39
MSCI Score	18	18	20	20
% Dominant Families				
Acarina	0.79	0.39	**2.06**	0.74
Asellidae	0.0	0.93	**4.19**	0.96
Baetidae	**9.46**	**2.56**	**4.05**	**2.95**
Caenidae	**5.13**	**3.95**	**7.42**	**10.93**
Chironomidae	**39.27**	**17.51**	**19.78**	**8.79**
Coenagrionidae	**2.60**	**2.17**	1.17	**3.25**
Elmidae	**3.15**	**18.51**	**12.71**	**8.12**
Helicopsychidae	0.0	0.39	**3.23**	**3.10**
Heptageniidae	1.42	**3.10**	**4.33**	**9.90**
Hyalellidae	**2.60**	**6.12**	**3.23**	**5.10**
Hydropsychidae	**9.54**	**2.32**	1.72	1.18
Leptoceridae	0.55	**2.48**	1.65	1.18
Leptohyphidae	**13.56**	**26.41**	**19.30**	**9.08**
Naididae	**1.89**	0.54	1.37	1.62
Planorbidae	**1.74**	0.15	0.14	0.30
Psephenidae	0.0	2.09	0.55	**6.94**

Top 10 families in bold.

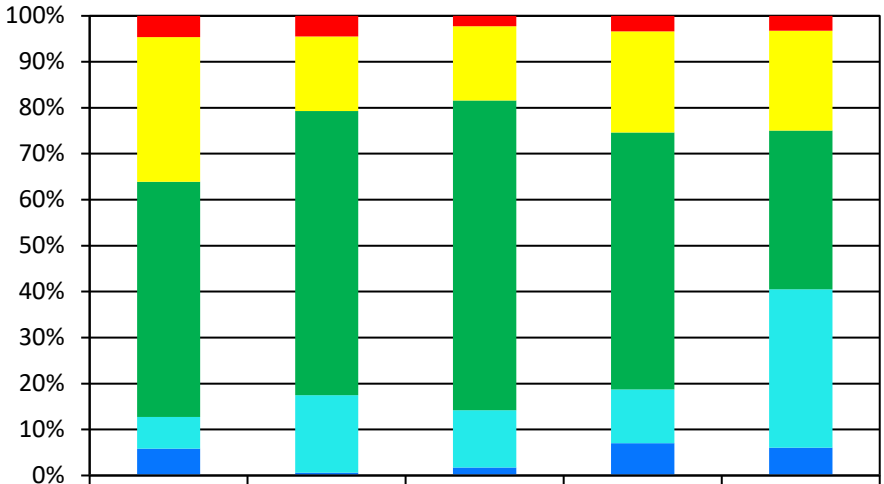
Figure 5: Fall 2020 Percent of Taxa by Functional Feeding Group



	EDU Bio Reference Samples	JC 11.9	JC 21.9	JC 25.2	JC 28.0
Filterer Collectors	20.81	29.58	24.39	19.39	11.38
Gatherer Collectors	44.22	44.77	46.53	46.22	39.08
Predators	8.07	5.06	3.79	5.98	5.17
Scrapers	22.73	11.95	20.56	22.72	41.74
Shredders	2.85	6.52	3.29	3.20	1.13
Other*	1.31	2.11	1.44	2.49	1.48

* Other includes parasites, macrophyte piercers, and taxa with no identified FFG

Figure 6: Fall 2020 Percent Sensitive Taxa by Biotic Index



	EDU Bio Reference Samples	JC 11.9	JC 21.9	JC 25.2	JC 28.0
>=9.0 Very Tolerant	4.6	4.5	2.3	3.4	3.3
7.5 - 8.9 Tolerant	31.5	16.2	16.2	22.0	21.7
5.0 - 7.4 Moderate	51.2	61.9	67.4	55.9	34.5
2.5 - 4.9 Intolerant	6.8	16.8	12.5	11.7	34.5
< 2.5 Very Intolerant	5.9	0.6	1.7	7.0	6.1

In spring 2021, Ephemeroptera had the highest abundance of EPT taxa among samples (Table 7), but Joachim Creek stations 21.9 and 25.2 had approximately 10 percent fewer Ephemeroptera than fall 2020 samples. Ephemeroptera families with highest abundance in spring samples were Baetidae, Caenidae, Heptageniidae, and Leptohyphidae (Table 7). *Caenis latipennis* and *Tricorythodes* made up a high percentage of invertebrates in spring samples. Stations 11.9 and 28.0 had a high abundance of *Acentrella* (BI = 4.0), where in fall 2020, *Baetis* (BI = 6.0) was more represented. Trichoptera abundance was variable among spring samples, but they made up a lower percentage of each sample compared to the fall (Tables 6 and 7). Unlike the fall samples, Plecoptera were found at all Joachim Creek stations in spring 2021 (Table 7). The greatest abundance and diversity of Plecoptera taxa occurred at station 28.0, and the fewest were in the station 11.9 sample. The percentage of Chironomidae ranged from 52.85 percent at station 11.9 to 18.43 percent at station 28.0 (Table 7).

Spring 2021 FFG in Joachim Creek were made up mainly of gatherer collectors (Figure 6), accounting for 46.10 percent to 69.06 percent of spring 2021 samples. Despite slight differences in gatherer collectors and scrapers, spring 2021 stations and duplicate FFG percentages had similar compositions (Figure 7).

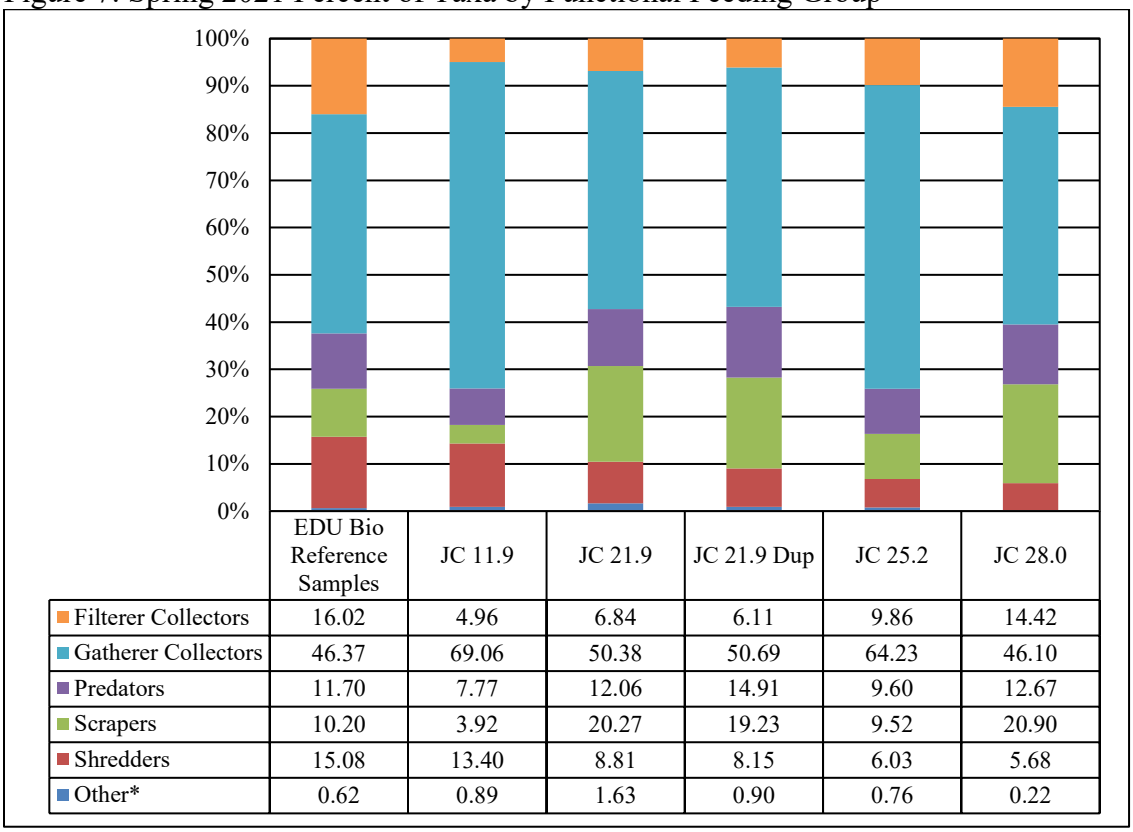
Joachim Creek contained primarily tolerant (BI 7.5 - 8.9), moderately tolerant (BI 5.0 - 7.4), and intolerant (BI 2.5 - 4.9) invertebrates in each sample (Figure 8). Joachim Creek station 28.0 had the highest percentage of very intolerant taxa.

Table 7: Spring 2021 Joachim Creek Riffle/Pool Macroinvertebrate Composition

	JC 11.9	JC 21.9a	JC 21.9b*	JC 25.2	JC 28.0
Collection Date	4/06/2021	4/06/2021	4/06/2021	4/06/2021	4/07/2021
Taxa Richness	73	86	85	81	100
Number EPT Taxa	21	25	24	24	31
% Ephemeroptera	35.97	22.75	25.59	21.41	31.03
% Plecoptera	0.81	1.28	1.30	1.36	4.95
% Trichoptera	1.26	5.47	3.18	1.95	3.93
MSCI Score	14	18	18	16	20
% Dominant Families					
Acarina	0.52	0.51	0.57	**3.14**	1.75
Asellidae	0.15	**2.91**	**3.02**	0.68	**3.79**
Baetidae	**7.40**	**2.48**	**1.79**	**1.95**	**8.16**
Caenidae	**25.02**	**8.47**	**10.68**	**13.76**	**12.24**
Chironomidae	**52.85**	**39.01**	**39.69**	**49.70**	**18.43**
Coenagrionidae	**0.59**	**1.80**	**2.04**	0.25	0.44
Corbiculidae	**0.67**	0.43	0.41	0.85	0
Elmidae	**2.59**	**10.95**	**12.39**	**7.39**	**7.94**
Heptageniidae	**0.96**	**2.74**	**4.32**	**1.19**	**3.57**
Hyalellidae	0.07	1.37	**2.12**	0.93	2.04
Leptohyphidae	**2.52**	**8.90**	**8.80**	**4.42**	**6.41**
Limoniidae	**0.96**	0	0	0	0.22
Naididae	0.44	0.77	0.98	**2.55**	0.29
Perlidae	**0.74**	0.77	0.90	1.10	**3.57**
Pleuroceridae	0.07	**5.82**	**3.50**	**2.63**	**9.03**
Simuliidae	0.44	**2.40**	1.06	**3.74**	**9.69**

Top 10 families in bold; *duplicate sample.

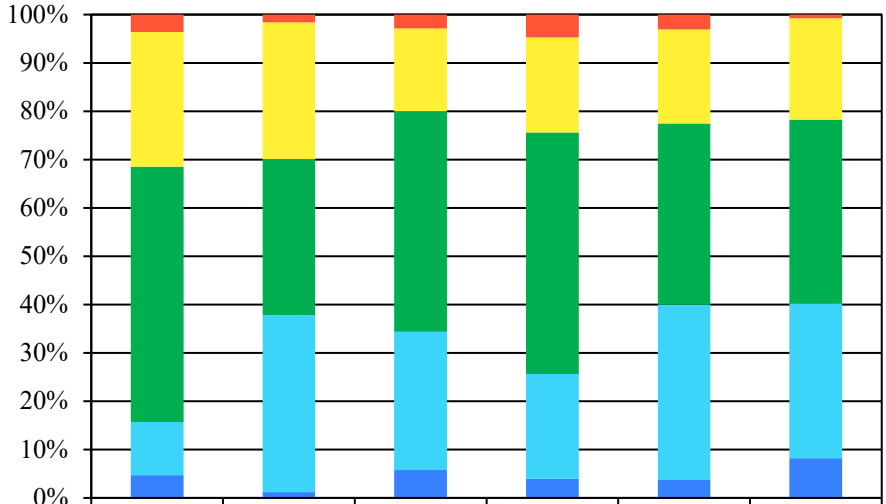
Figure 7: Spring 2021 Percent of Taxa by Functional Feeding Group



	EDU Bio Reference Samples	JC 11.9	JC 21.9	JC 21.9 Dup	JC 25.2	JC 28.0
Filterer Collectors	16.02	4.96	6.84	6.11	9.86	14.42
Gatherer Collectors	46.37	69.06	50.38	50.69	64.23	46.10
Predators	11.70	7.77	12.06	14.91	9.60	12.67
Scrapers	10.20	3.92	20.27	19.23	9.52	20.90
Shredders	15.08	13.40	8.81	8.15	6.03	5.68
Other*	0.62	0.89	1.63	0.90	0.76	0.22

* Other includes parasites, macrophyte piercers, and taxa with no identified FFG

Figure 8: Spring 2021 Percent Sensitive Taxa by Biotic Index



	EDU Bio Reference Samples	JC 11.9	JC 21.9	JC 21.9 Dup	JC 25.2	JC 28.0
>=9.0 Very Tolerant	3.6	1.6	2.8	4.7	3.1	0.7
7.5 - 8.9 Tolerant	27.9	28.2	17.2	19.6	19.5	21.0
5.0 - 7.4 Moderate	52.8	32.4	45.6	50.0	37.4	38.0
2.5 - 4.9 Intolerant	11.0	36.6	28.6	21.6	36.3	32.0
< 2.5 Very Intolerant	4.7	1.2	5.8	4.0	3.7	8.2

3.4.2 Macroinvertebrate Stream Condition Index (MSCI) Scores

All Joachim Creek stations attained fully supporting MSCI scores in fall 2020 using Ozark/Apple/Joachim EDU scoring criteria (Table 8). The two upstream stations had the highest possible MSCI score, with each of the individual biological metrics scoring in the optimal range. For the two downstream sites, stations 11.9 and 21.9, three of the four individual metrics had optimal scores; TR was the only metric with a suboptimal score.

Table 8: Fall 2020 Joachim Creek Riffle/Pool Metric Values and Scores Using Ozark/Apple/Joachim Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
JC 11.9	$77_{(3)}$	$22_{(5)}$	$6.1_{(5)}$	$3.37_{(5)}$	18	**F**
JC 21.9	$75_{(3)}$	$21_{(5)}$	$5.8_{(5)}$	$3.09_{(5)}$	18	**F**
JC 25.2	$87_{(5)}$	$22_{(5)}$	$5.7_{(5)}$	$3.41_{(5)}$	20	**F**
JC 28.0	$90_{(5)}$	$25_{(5)}$	$5.1_{(5)}$	$3.31_{(5)}$	20	**F**
Metric Score=5	>81	>20	<6.3	>2.76	20-16	**F**ull
Metric Score=3	81-41	20-10	6.3-8.1	2.76-1.38	14-10	**P**artial
Metric Score=1	<41	<10	>8.1	<1.38	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF samples (n = 10). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

With the exception of station 11.9, each of the Joachim Creek sites attained fully supporting MSCI scores in spring 2021 (Table 9). Station 11.9 had a partially supporting MSCI score of 14, with BI being the only individual metric with an optimal score. Station 28.0 was the only site with an MSCI score of 20. Duplicate samples collected at station 21.9 had MSCI scores of 18, with TR being the only suboptimal individual metric. Although station 25.2 had a fully supporting MSCI score, TR and SDI were suboptimal.

Table 9: Spring 2021 Joachim Creek Riffle/Pool Metric Values and Scores Using Ozark/Apple/Joachim Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
JC 11.9	$73_{(3)}$	$21_{(3)}$	$5.7_{(5)}$	$2.72_{(3)}$	14	**P**
JC 21.9	$86_{(3)}$	$25_{(5)}$	$5.4_{(5)}$	$3.46_{(5)}$	18	**F**
JC 21.9 Dup	$85_{(3)}$	$24_{(5)}$	$5.7_{(5)}$	$3.50_{(5)}$	18	**F**
JC 25.2	$81_{(3)}$	$24_{(5)}$	$5.5_{(5)}$	$3.07_{(3)}$	16	**F**
JC 28.0	$100_{(5)}$	$31_{(5)}$	$5.1_{(5)}$	$3.51_{(5)}$	20	**F**
Metric Score=5	>91	>21	<6.4	>3.17	20-16	**F**ull
Metric Score=3	91-45	21-11	6.4-8.2	3.17-1.59	14-10	**P**artial
Metric Score=1	<45	<11	>8.2	<1.59	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF samples (n = 14). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

3.5 Duplicate Sample Results

A duplicate physicochemical sample was collected at Joachim Creek station 21.9 during spring 2021. The duplicate sample difference criteria for the physicochemical parameters are specified in the Fiscal Year 2021 Quality Assurance Project Plan (MoDNR 2020). Turbidity and nitrate plus nitrite-nitrogen exceeded the duplicate relative percent difference criteria of 20 percent (Table 4). This may have occurred because both parameters were present in very low concentrations, and small absolute differences yielded relative percent difference values that exceeded 20 percent.

Quantitative Similarity Index for Taxa (**QSIT**) is a sampling protocol quality control measure that expresses taxa similarity between two samples as a percentage. Duplicate samples are expected to have a score of 70 percent or greater (Rabeni et al. 1999). A QSIT of 80.4 percent was calculated for the duplicate macroinvertebrate samples collected at Joachim Creek 21.9 during the spring of 2021.

4.0 Discussion

4.1 Land Use

Joachim Creek is located in the upper portion of the Ozark/Apple/Joachim EDU and flows through several municipalities including De Soto, Festus, and Herculaneum. Although land use is primarily deciduous forest and hay/pasture fields containing little developed area (Table 1), many sites sampled are located in aforementioned urban municipalities (Figure 3). Water resources affected by urbanization may experience increased volume of runoff and reduced infiltration (Tang et al. 2005, Walsh et al. 2005). Storm water and urban flooding events contribute to non-point source pollution (Allan 2004; Carle et al. 2005; Paul and Meyer 2001). Streams in urban areas tend to have increased concentrations of nutrients and contaminants as well as macroinvertebrate communities with reduced biotic richness and increased dominance of tolerant taxa (Allan 2004, Paul and Meyer 2001, Walsh et al. 2005).

4.2 Stream Habitat

Instream habitat and surrounding catchment variables influence aquatic community composition (Wang et al. 2007, Burdon et al. 2013). Epifaunal substrate scored well in all stations except at 11.9, the most downstream area. Joachim Creek station 11.9 was incomparable to the BIOREF stream because it scored <75 percent of the reference stream SHAPP score. Station 11.9 is the closest sample site to the Mississippi River and is located relatively close to the alluvial plain. Since only 11.9 river miles separate this station from the Mississippi River, it is likely that backflow can occur when the river level is high, which may explain why the station scored poorly with sediment deposition and epifaunal substrate. Stream gradient may also affect sedimentation at station 11.9. As the Joachim Creek study reach approaches the Mississippi River, gradient decreases from 31.7 feet/mile at station 28.0 to 13.2 feet/mile at station 11.9. The stream reach downstream of station 11.9 has a gradient of 0.5 feet/mile. As gradient and velocity decrease, a stream's ability to transport sediment also decreases until eventually the finer

sediment also falls out of suspension and is deposited on the stream bed (Church 2006). Sedimentation homogenizes the stream bed by filling interstitial spaces of the substrate and occupies potential macroinvertebrate habitat. Station 11.9 also had steep banks of clay, rocky bluffs devoid of vegetative protection, and poor riffle quality. These factors contributed to a lower habitat score compared to other stations and the habitat assessment control site.

4.3 Physicochemical Analysis and Fine Sediment

During fall 2020, turbidity for station 11.9 was 8.08 NTU (Table 3). The high turbidity may have resulted from upstream construction located near Highway A in Festus, Missouri. Spring 2021 turbidity surpassed EPA recommendations across all stations after precipitation in the surrounding area (Table 4; USEPA 2000).

Nitrate plus nitrite as N and total nitrogen were elevated compared to EPA's recommended values at station 11.9 during fall 2020 and spring 2021 (Table 3 and 4). EPA's recommended total phosphorus value was surpassed in all stations for both sampling seasons. High levels of nutrients can result in degraded aquatic communities (Dodds et al. 2009, Waite and Van Metre 2017, Wang et al. 2007). Excessive nutrients have been identified as a major reason why water quality objectives, such as support of aquatic life, fail (USEPA 2000).

The Old Lead Belt, Mine La Motte-Fredericktown, and Viburnum Trend make up the Southeast Missouri Lead District, which contains the highest concentrations of lead sulfide in the world (Kleeschulte 2008). Johnson et al. (2016) found the highest concentrations of metals contamination is associated with geographical locations of mining. Increased levels of metals contamination in soils and water columns in mining districts can accumulate and persist within the environment. Surface water runoff through mine tailings piles and groundwater from abandoned mines can transport contaminated soils and water throughout the watershed. Concentrations of metals in benthic stream sediments in sufficient amounts to result in toxicity to aquatic life or that harm benthic organisms violate the general criteria of Missouri's WQS. Per 10 CSR 20-7.031(4)(D) of the WQS, "waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life."

Despite a high density of historical mining in the watershed, dissolved metals concentrations and metals located in fine sediment were below PEQ values at all four stations (Tables 3, 4, and 5).

4.4 Biological Assessment and Macroinvertebrate Community Composition

During the fall 2020 field season, all four Joachim Creek stations had MSCI scores that were fully supporting of the protection of warm water habitat designated use. When comparing fall samples to Ozark/Apple/Joachim EDU BIOREF criteria, Joachim Creek scored well for EPTT, BI, and SDI; however, stations 11.9 and 21.9 had suboptimal scores for TR. Both urban areas (i.e. stations 11.9 and 25.2) experienced declines in

MSCI scores during the spring 2021 sampling season, with station 11.9 attaining a partially supporting score.

Although Joachim Creek generally had high EPTT scores in both sampling seasons, Plecoptera were consistently scarce compared to Ephemeroptera and Trichoptera. This is not an unusual occurrence as samples collected from BIOREF streams in the Ozark/Apple/Joachim EDU also have low Plecoptera relative abundance. Plecoptera make up an average of 0.10 percent of fall BIOREF samples and 1.26 percent of spring samples. Plecoptera abundance for most Joachim Creek spring samples was similar to BIOREF samples. Station 28.0, however, had a much higher percentage of Plecoptera than the average among BIOREF samples. Commonly, EPTT abundance and richness declines are linked to urbanization and point source pollution near sample sites (Poulton and Tao 2020). Lenat and Crawford (1994) found that streams in urban settings suffer from low taxa richness, low abundance, and high biotic index values, which is somewhat consistent with the lower spring MSCI scores at stations 11.9 and 25.2.

As Joachim Creek approaches the Mississippi River, the habitat changes from rocky substrate to larger sandy runs and pools. Station 11.9 habitat scored poorly primarily due to high sediment and poor epifaunal substrate (Table 2). This change in habitat and sedimentation is reflected in macroinvertebrate communities among sample stations along the stream gradient. In lowland streams with slower flowing water, settling sediments may affect the viability of certain lotic invertebrate eggs (Kefford et al. 2010). Aquatic EPT taxa occurrence is connected to their ability to capitalize on food resources located in a stream's habitat (Wallace and Webster 1996). Increased fine sediment in downstream Joachim Creek may influence taxa richness, density, and traits of EPT macroinvertebrates (Akamagwuna et al. 2019, Zweig and Rabeni 2001). Consequently, representation of more tolerant invertebrate taxa (e.g. Chironomidae) increased as sampling stations were in closer proximity to the Mississippi River.

Bioassessment data demonstrated a general reduction of scrapers and an increase in gatherer collectors as the stations progress downstream toward the Mississippi River. Because FFGs respond to anthropogenic effects on aquatic systems, stressed aquatic conditions are often manifested in FFG categories. Specialist FFG categories have specific feeding needs that may be limited in impaired systems, whereas generalist FFGs are thought to be more tolerant due to their ability to use a wider array of available food resources. Generalist categories, such as gatherer-collectors and filterer-collectors, increase in response to increased pollution or disturbances while specialists such as scrapers decrease (Barbour et al. 1999).

Joachim Creek flows through several urban municipalities with WWTP outfalls and other point source discharges. Urban areas and WWTPs often contribute to declines in aquatic communities and biotic integrity (Dyer and Wang 2002). Runoff from impervious surfaces and point source discharges can introduce contaminants and excess nutrients into

waterways (Carpenter et al. 1998), causing taxa richness declines in aquatic communities (Paul and Meyer 2001).

5.0 Conclusions

The Joachim Creek watershed consists primarily of deciduous forest and hay/pasture fields. However, it also flows through the center of De Soto and is subject to several water quality influences including WWTP discharge and urban surface runoff. Non-point source inputs may also be increased by urban flooding, which De Soto experienced in 2018 (Carle et al. 2005; Heimann et al. 2018). These stressors on Joachim Creek may cause adverse effects on stream water quality and aquatic life. Additionally, many past and present mining sites (e.g. lead, barium, zinc, etc.) are scattered across the watershed, and ore was historically smelted in Herculaneum, Missouri. Elevated dissolved metal concentrations or metals associated with the fine sediment may be potentially toxic to the benthic-dwelling macroinvertebrate community.

Despite the anthropogenic activities surrounding Joachim Creek, all MSCI scores were in the fully supporting category, with the exception of a partially supporting score at station 11.9 in spring 2021. No Missouri WQS were violated; however, some nutrient concentrations slightly exceeded EPA's recommended values. Dissolved metals and sediment samples were below hardness dependent water quality standards and respective PEC limits.

6.0 References Cited

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Appendix A

Macroinvertebrate Database Bench Sheet Report
Fall 2020 and Spring 2021

Joachim Creek, Jefferson County, Missouri

Grouped by Season and Station

Fall 2020 Macroinvertebrate Bench Sheet Report			
Sep 15, 2020 Joachim Creek - ab. Main St. [1719_11.9] - 20079			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		4	6
AMPHIPODA			
Gammarus			27
Hyalella azteca			33
ARHYNCHOBDELLIDA			
Erpobdellidae	*		
BASOMMATOPHORA			
Ancylidae			2
Menetus			22
Physella			4
COLEOPTERA			
Berosus			3
Dubiraphia		4	16
Macronychus glabratus			4
Scirtidae			1
Stenelmis	8	6	
DECAPODA			
Palaemonetes kadiakensis			*
DIPTERA			
Ablabesmyia		4	2
Ceratopogoninae		4	1
Chironomus	1	2	2
Cladotanytarsus	26	132	3
Cricotopus bicinctus	3		3
Cricotopus/Orthocladius	2		35
Cryptochironomus	22	6	
Cryptotendipes		2	1
Dicrotendipes	1	5	5
Dixa			1
Dixella			3
Forcipomyiinae			1
Labrundinia		1	4
Microtendipes	3		
Nilotanypus	2		
Parachironomus			4
Paralauterborniella		3	1
Paratanytarsus		3	5
Polypedilum flavum	45		
Polypedilum halterale grp	1	7	
Polypedilum illinoense grp	3		12
Polypedilum scalaenum grp	1	9	3
Procladius		1	
Pseudochironomus	2	1	2
Rheotanytarsus	22		5
Saetheria	9		
Stempellina		2	
Stempellinella	3	27	
Stenochironomus		1	1
Stictochironomus	1		
Tanytarsus	10	14	26
Telopelopia	1		
Thienemanniella	3		
Thienemannimyia grp	2		1
EPHEMEROPTERA			
Apobaetis		1	
Baetis	87		
Baetiscidae			
Caenis anceps	35	8	5

Caenis latipennis		6	8
Choroterpes		2	
Hexagenia limbata		1	1
Isonychia bicolor	1		
Leptophlebiidae	1	1	
Plauditus	22		
Procloeon	3	5	2
Stenonema femoratum		1	
Stenonema mediopunctatum	1		
Stenonema pulchellum	16		
Tricorythodes	164	3	5
LUMBRICINA			
Lumbricina	1		
ODONATA			
Argia			21
Enallagma			12
Gomphidae		2	
Macromia		*	
TRICHOPTERA			
Cernotina		1	
Cheumatopsyche	121		
Chimarra	20		
Cyrnellus fraternus			3
Hydroptila	4		
Mystacides	1		
Oecetis	5	1	
Oxyethira			1
TUBIFICIDA			
Branchiura sowerbyi	1	6	2
Tubificinae	5	7	1
VENEROIDA			
Corbicula	14		4

Sep 15, 2020 Joachim Creek - ab. De Soto WWTP [1719_21.9] - 20080			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	2		3
AMPHIPODA			
Gammarus	1	4	1
Hyalella azteca			79

BASOMMATOPHORA			
Lymnaeidae			2
Menetus			2
COLEOPTERA			
Ancyronyx variegatus			2
Dubiraphia	36	14	28
Ectopria nervosa		1	
Macronychus glabratus			14
Microcylloepus pusillus	*		6
Psephenus herricki	17	9	
Stenelmis	62	62	14
DECAPODA			
Faxonius luteus	3	*	
Faxonius virilis			1
DIPTERA			
Ablabesmyia		12	2
Anopheles			3
Atherix	4		
Chironomidae		1	
Chironomus		6	
Cladotanytarsus		4	
Corynoneura		1	
Cricotopus/Orthocladius			7
Cryptochironomus	1	2	
Dicrotendipes		1	1
Hemerodromia	2		
Microtendipes			1
Paratanytarsus		1	4
Polypedilum flavum	9		1
Polypedilum halterale grp		3	
Polypedilum illinoense grp	1		4
Polypedilum scalaenum grp	1	8	
Procladius		1	
Rheotanytarsus	12		6
Stempellina			1
Stempellinella	11	44	21
Stenochironomus			1
Tabanus	*		
Tanytarsus	1	9	33
Thienemanniella		1	1
Thienemannimyia grp	9	1	1

Tribelos			2
EPHEMEROPTERA			
Baetis	26		
Caenis anceps	25	5	
Caenis latipennis		9	12
Procloeon		3	4
Stenacron		3	
Stenonema femoratum		4	
Stenonema mediopunctatum	6		
Stenonema pulchellum	23		
Stenonema terminatum	4		
Tricorythodes	315	21	4
ISOPODA			
Caecidotea	10	2	
LEPIDOPTERA			
Petrophila	*		
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			
Lumbriculidae	*		
NEOTAENIOGLOSSA			
Elimia	40	13	5
ODONATA			
Argia	2	5	10
Enallagma			11
Hagenius brevistylus		*	1
Stylogomphus albistylus	*		
PLECOPTERA			
Acroneuria	*		
TRICHOPTERA			
Cernotina		1	1
Cheumatopsyche	27	1	
Chimarra	5		
Helicopsyche	4	1	
Hydropsyche	2		
Hydroptila		14	2
Mystacides		3	
Nectopsyche		2	1
Oecetis		5	7
Triaenodes			14
TRICLADIDA			
Planariidae	15	2	2
TUBIFICIDA			
Branchiura sowerbyi		5	
Tubificinae		2	
VENEROIDA			
Corbicula	9	1	

Sep 15, 2020 Joachim Creek - 0.1 mi. bl. Hwy E [1719_25.2] - 20081			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	14	15	1
AMPHIPODA			
Hyalella azteca	1	1	45
BASOMMATOPHORA			
Ancylidae		1	3
Menetus	1		1
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Ancyronyx variegatus			3
Berosus			2
Dubiraphia	5	4	16
Ectopria nervosa		1	1
Macronychus glabratus		1	6
Microcylloepus pusillus	28		12
Optioservus sandersoni		1	1
Psephenus herricki	4	2	
Stenelmis	81	11	16
DECAPODA			
Faxonius luteus	*	*	*
DIPTERA			
Ablabesmyia	3	6	19
Atherix	*		
Cardiocladius	1		
Ceratopogoninae		1	1
Chironomidae	3	1	
Corynoneura	2		2
Cricotopus bicinctus	4		
Cricotopus/Orthocladius	3	6	
Cryptochironomus			1

Cryptotendipes			2
Dicrotendipes	6	1	3
Labrundinia		3	
Nanocladius	1	1	
Nilotanypus	4		
Paralauterborniella			1
Paratanytarsus	5	29	7
Pentaneura	6		
Polypedilum flavum	27	1	
Polypedilum illinoense grp	1	6	
Polypedilum scalaenum grp			3
Procladius			1
Rheotanytarsus	5	7	
Stempellinella	17	1	20
Stenochironomus	1		1
Stratiomys		1	
Tanytarsus	20	5	18
Thienemanniella	2		
Thienemannimyia grp	11	1	2
Tribelos			15
EPHEMEROPTERA			
Baetis	46		
Caenis anceps	6	7	3
Caenis latipennis	24	56	10
Callibaetis			4
Choroterpes	2	1	
Isonychia bicolor	6		
Procloeon	1	7	1
Stenacron	10	5	1
Stenonema femoratum		2	
Stenonema mediopunctatum	4	1	
Stenonema pulchellum	38		2
Tricorythodes	259	18	3
HEMIPTERA			
Microvelia			1
Rhagovelia			2
ISOPODA			
Caecidotea	58		3
LUMBRICINA			
Lumbricina	3		
MEGALOPTERA			
Corydalus	2		
NEOTAENIOGLOSSA			
Elimia	74	6	8
Hydrobiidae		1	
ODONATA			
Calopteryx			1
Enallagma			17
Gomphidae	1		
Hagenius brevistylus			1
Libellula			1
Macromia		*	
Stylogomphus albistylus		*	
PLECOPTERA			
Perlidae	4		
RHYNCHOBDELLIDA			
Glossiphoniidae			1
TRICHOPTERA			
Ceraclea		1	
Cernotina	1		
Cheumatopsyche	20		5
Chimarra	1		
Helicopsyche	45	2	
Hydroptila	17	5	8
Mystacides		3	
Oecetis		5	4
Triaenodes		3	6
TRICLADIDA			
Planariidae	26		
TUBIFICIDA			
Aulodrilus		1	
Branchiura sowerbyi	3		
Tubificinae	5		10
VENEROIDA			
Corbicula	4	2	1
Pisidiidae		1	

Sep 16, 2020 Joachim Creek - ab. Hammon Rd. [1719_28.0] - 20082			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	2	1	3

AMPHIPODA			
Hyalella azteca		1	68
BASOMMATOPHORA			
Ancylidae	2		18
Helisoma			1
Menetus			3
Physella			2
COLEOPTERA			
Dubiraphia		14	30
Ectopria nervosa	1	4	8
Enochrus	1		
Helichus basalis			1
Macronychus glabratus			1
Microcylloepus pusillus	6	2	13
Peltodytes			1
Psephenus herricki	58	23	
Scirtidae			2
Stenelmis	23	13	8
DECAPODA			
Faxonius luteus	2		*
Faxonius virilis			*
DIPTERA			
Ablabesmyia		7	1
Aedes			1
Anopheles	2		2
Atherix	*		*
Ceratopogoninae		2	
Chironomidae			1
Chrysops		1	
Corynoneura		1	3
Cryptochironomus		1	
Dicrotendipes		1	3
Dixella			1
Forcipomyiinae	1		
Labrundinia		1	3
Microtendipes		3	8
Nanocladius		1	
Natarsia		3	
Paratanytarsus			2
Polypedilum flavum	2		
Polypedilum illinoense grp			3

Rheotanytarsus	4		
Simulium	4		
Stempellinella	2	13	2
Synorthocladius		2	
Tabanus	*		
Tanytarsus	1	3	26
Thienemannimyia grp	2		1
Tribelos		14	3
EPHEMEROPTERA			
Ameletus ludens	*		
Baetidae			2
Baetis	35		1
Caenis anceps	20	2	
Caenis latipennis	3	101	13
Eurylophella			2
Isonychia bicolor	2		
Leptophlebiidae	9	4	
Procloeon		2	
Stenacron	9	8	
Stenonema femoratum	1	7	1
Stenonema mediopunctatum	4		
Stenonema pulchellum	65		1
Stenonema terminatum	36		1
Tricorythodes	117	3	3
HEMIPTERA			
Ranatra kirkaldyi			*
Rhagovelia	1		
Veliidae			2
ISOPODA			
Caecidotea	9	3	1
LUMBRICINA			
Lumbricina	1	*	
MEGALOPTERA			
Corydalus	1		
Sialis		1	
NEOTAENIOGLOSSA			
Elimia	177	34	24
ODONATA			
Argia	23	4	5
Basiaeschna janata			*
Enallagma			7

Gomphidae	11	1	
Hagenius brevistylus		1	
Ischnura			5
Macromia			*
Stylogomphus albistylus	*	*	
PLECOPTERA			
Acroneuria	*	*	
TRICHOPTERA			
Cernotina			2
Cheumatopsyche	11		4
Chimarra	4		2
Helicopsyche	36	3	2
Hydropsyche	1		
Hydroptila		14	1
Oecetis			3
Pycnopsyche			*
Triaenodes		1	12
TRICLADIDA			
Planariidae	2		
TUBIFICIDA			
Branchiura sowerbyi		2	
Tubificinae		20	
VENEROIDA			
Corbicula	*	*	

Spring 2021 Macroinvertebrate Bench Sheet Report			
Apr 06, 2021 Joachim Creek - ab. Main St. [1719_11.9] - 21019			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		4	3
AMPHIPODA			
Crangonyx		1	3
Hyalella azteca			1
BASOMMATOPHORA			
Lymnaeidae	1		
Physella		7	
COLEOPTERA			
Berosus		1	1
Dubiraphia		2	3
Dytiscidae			*
Lutrochus	1		
Microcylloepus pusillus	1		
Peltodytes		1	1
Psephenus herricki	1		
Stenelmis	19	8	2
DIPTERA			
Ablabesmyia		4	15
Ceratopogoninae		6	1
Chironomidae			
Chironomus		1	1
Cladotanytarsus	74	106	7
Clinocera	2		
Corynoneura	1		1
Cricotopus/Orthocladius	90	21	35
Cryptochironomus	27	3	
Diamesa	1		
Dicrotendipes		2	3
Diptera	1	3	
Erioptera	8	1	
Eukiefferiella	170	10	1
Gonomyia	4		
Hemerodromia	1		
Microtendipes	2		
Myxosargus			1
Polypedilum flavum	11		5
Polypedilum halterale grp	3	4	2
Polypedilum scalaenum grp	1	3	4
Pseudochironomus	7		
Rheotanytarsus	2		4
Simulium	6		
Stempellinella	2	3	2
Stictochironomus	4		
Sympotthastia	8		
Tanytarsus	5	12	23
Thienemanniella	11	2	2
Thienemannimyia grp	5	1	7
EPHEMEROPTERA			
Acentrella	98		2
Caenis latipennis	58	83	196
Isonychia	1		
Stenacron		2	
Stenonema femoratum		1	5
Stenonema mediopunctatum			1
Stenonema pulchellum			4
Tricorythodes	21	6	7
ISOPODA			
Caecidotea		1	1
NEOTAENIOGLOSSA			
Elimia			1
ODONATA			
Argia	1		1
Calopteryx			1
Dromogomphus			*
Enallagma			6
PLECOPTERA			
Isoperla	1		
Perlesta	5		5
TRICHOPTERA			
Cheumatopsyche	2		
Chimarra	1		
Helicopsyche	1		
Hydroptila	1		2
Ironoquia			*

Mystacides		1	1
Nyctiophylax			1
Oecetis	4		
Plectrocnemia			*
Rhyacophila	1		
Triaenodes			1
TUBIFICIDA			
Branchiura sowerbyi			
Enchytraeidae	1		
Limnodrilus hoffmeisteri		1	
Tubificinae	1	3	
VENEROIDA			
Corbicula	7	2	

Apr 06, 2021 Joachim Creek - ab. De Soto WWTP [1719_21.9] - 21020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	3	2	1
AMPHIPODA			
Crangonyx	2	*	
Gammarus		1	
Hyalella azteca	1		15
BASOMMATOPHORA			
Ancylidae			2
Physella	1	1	
BRANCHIOBDELLIDA			
Branchiobdellida	1		
COLEOPTERA			
Ancyronyx variegatus			1
Dubiraphia		4	4
Ectopria nervosa	1		
Lutrochus	1		
Macronychus glabratus			2
Microcylloepus pusillus	12	1	12
Psephenus herricki	14	3	1
Stenelmis	50	39	3
DECAPODA			
Faxonius luteus	4	*	*
DIPTERA			
Ablabesmyia		57	4

Ceratopogoninae	1	1	
Cladotanytarsus		6	
Clinocera	5	1	
Corynoneura			4
Cricotopus/Orthocladius	23	2	6
Cryptochironomus		2	
Dicrotendipes		2	2
Diptera			1
Eukiefferiella	121	3	29
Hemerodromia	4		
Hydrobaenus			1
Labrundinia			4
Micropsectra	1		1
Orthocladius (Euorthocladius)		1	
Parametriocnemus	2		
Paratanytarsus			14
Phaenopsectra		2	
Polypedilum fallax grp			1
Polypedilum flavum	27		2
Polypedilum scalaenum grp	3	11	11
Prosimulium			1
Psectrocladius			1
Pseudorthocladius	1		
Rheotanytarsus	5	1	6
Simulium	5		22
Stempellinella	17	13	1
Stictochironomus	4	22	
Tanytarsus	6	8	15
Thienemanniella	1		3
Thienemannimyia grp	8	1	1
Tipula	1		
EPHEMEROPTERA			
Acentrella	7		
Acerpenna	1		
Baetis	18		
Caenis latipennis	55	32	12
Isonychia bicolor	1		
Leptophlebiidae		1	
Plauditus	2		1
Stenacron	4		
Stenonema femoratum	1		*

Stenonema mediopunctatum	2		
Stenonema pulchellum	20		
Stenonema terminatum	5		
Tricorythodes	97	2	5
ISOPODA			
Caecidotea	6	1	27
LEPIDOPTERA			
Noctuidae	1		
Petrophila	1		
LUMBRICINA			
Lumbricina	*	*	
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	52	3	13
ODONATA			
Enallagma			20
Ischnura			1
Macromia			*
PLECOPTERA			
Isoperla	6		
Perlesta	8		1
TRICHOPTERA			
Cernotina		3	
Cheumatopsyche	2		1
Chimarra	1		
Helicopsyche	18		
Hydropsyche	1		
Hydroptila	15	1	2
Nectopsyche		3	5
Oecetis	2	1	2
Rhyacophila	1		
Triaenodes			6
TRICLADIDA			
Planariidae	2		2
TUBIFICIDA			
Limnodrilus hoffmeisteri		2	
Tubificinae		6	1
VENEROIDA			
Corbicula	3	2	

Apr 06, 2021 Joachim Creek - ab. De Soto WWTP [1719_21.9] - 21021 (duplicate sample)			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	2	5	
AMPHIPODA			
Gammarus	3	2	
Hyalella azteca			26
Stygobromus		1	
BASOMMATOPHORA			
Ancylidae			1
Physella			1
COLEOPTERA			
Ancyronyx variegatus			4
Dubiraphia		6	4
Ectopria nervosa		1	
Macronychus glabratus			3
Microcylloepus pusillus	15		9
Psephenus herricki	18	2	
Stenelmis	46	57	8
DECAPODA			
Faxonius luteus	3	1	*
DIPTERA			
Ablabesmyia		45	17
Cardiocladius			1
Cladotanytarsus		4	
Clinocera	6	1	
Corynoneura	1	3	12
Cricotopus/Orthocladius	8	1	18
Cryptochironomus		3	
Dicrotendipes		2	3
Diptera		1	
Eukiefferiella	92	6	23
Labrundinia			3
Microtendipes		1	1
Natarsia		1	
Nilotanypus	5		
Parametriocnemus	3		
Paratanytarsus			15
Paratendipes	2	23	7
Pentaneura			1

Phaenopsectra		1	3
Polypedilum fallax grp	1		1
Polypedilum flavum	17		4
Polypedilum illinoense grp			19
Polypedilum scalaenum grp	5	14	
Rheocricotopus	1		
Rheotanytarsus	8		4
Simulium	6		7
Stempellinella	22	6	1
Stictochironomus		1	
Tanytarsus	5	8	25
Thienemanniella		1	
Thienemannimyia grp	20	14	4
Tipula	*		
Xenochironomus			1
EPHEMEROPTERA			
Acentrella	3		
Baetis	17		1
Caenis latipennis	54	53	24
Diphetor	1		
Stenacron	15		
Stenonema femoratum	1		*
Stenonema mediopunctatum	5		
Stenonema pulchellum	10		
Stenonema terminatum	22		
Tricorythodes	97	5	6
ISOPODA			
Caecidotea	19	4	14
LUMBRICINA			
Lumbricina	2		
MEGALOPTERA			
Corydalus	3		
NEOTAENIOGLOSSA			
Elimia	31	4	8
ODONATA			
Basiaeschna janata			*
Enallagma			25
Hagenius brevistylus	1		*
Hetaerina			1
PLECOPTERA			
Isoperla	5		
Perlesta	10		1
TRICHOPTERA			
Cernotina		1	
Cheumatopsyche	2		1
Chimarra	2		
Helicopsyche	2		
Hydroptila	7		3
Mystacides			2
Oecetis	1	1	1
Plectrocnemia	1		
Polycentropus		*	1
Pycnopsyche			*
Rhyacophila	1	1	
Triaenodes		4	8
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Branchiura sowerbyi	3		
Enchytraeidae	1	1	
Limnodrilus hoffmeisteri		3	
Tubificinae		5	1
VENEROIDA			
Corbicula	2	2	1

Apr 06, 2021 Joachim Creek - 0.1 mi. bl. Hwy E [1719_25.2] - 21022			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	22	15	
AMPHIPODA			
Crangonyx		8	6
Hyalella azteca		3	8
ARHYNCHOBDELLIDA			
Erpobdellidae	*	*	
BASOMMATOPHORA			
Helisoma	*		
BRANCHIOBDELLIDA			
Branchiobdellida	1		
COLEOPTERA			
Dubiraphia	2	9	3
Ectopria nervosa		*	1

Lutrochus	1		
Microcylloepus pusillus	14	1	5
Psephenus herricki	2	1	
Stenelmis	39	10	4
DECAPODA			
Faxonius luteus	*		*
Faxonius virilis			1
DIPTERA			
Ablabesmyia		22	3
Ceratopogoninae		1	
Cladotanytarsus		4	
Clinocera	2		
Corynoneura	5	2	13
Cricotopus/Orthocladius	19	1	16
Cryptochironomus		2	
Diptera		1	
Eukiefferiella	140	4	164
Hemerodromia	6		
Hydrobaenus	1		1
Labrundinia	2	1	7
Orthocladius (Euorthocladius)	1		
Paratanytarsus	1		3
Polypedilum fallax grp			1
Polypedilum flavum	6	1	2
Polypedilum halterale grp		1	
Polypedilum scalaenum grp	5	11	4
Rheocricotopus	1		
Rheotanytarsus	5		2
Simulium	42		2
Stempellinella	14	11	3
Stictochironomus		43	
Tabanus	*		
Tanytarsus	10	33	10
Thienemanniella			2
Thienemannimyia grp	5	1	2
Tipula	*		*
EPHEMEROPTERA			
Acentrella	10		4
Acerpenna	2		1
Caenis anceps	4	8	
Caenis latipennis	59	47	44

Fallceon			1
Paraleptophlebia		1	
Plauditus	2		3
Stenonema femoratum	1	2	
Stenonema pulchellum	6	1	1
Stenonema terminatum	3		
Tricorythodes	43	4	5
ISOPODA			
Caecidotea	5	2	1
LEPIDOPTERA			
Petrophila			*
LUMBRICINA			
Lumbricina	1		
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	19	3	9
ODONATA			
Basiaeschna janata			*
Boyeria			1
Enallagma			3
Hagenius brevistylus		*	
Macromia		*	
Stylogomphus sigmastylus	*		
PLECOPTERA			
Amphinemura			1
Isoperla	2		
Neoperla	2		
Perlesta	10		1
TRICHOPTERA			
Chimarra	1		
Helicopsyche	7	1	
Hydropsyche	1		
Hydroptila	4	2	2
Nectopsyche	1		
Oecetis	1	1	
Polycentropus		1	
Rhyacophila	*		
Triaenodes			1
TRICLADIDA			
Planariidae	5	1	1

TUBIFICIDA			
Limnodrilus hoffmeisteri	1	1	
Tubificinae	7	21	
VENEROIDA			
Corbicula	7	1	2

Apr 07, 2021 Joachim Creek - ab. Hammon Rd. [1719_28.0] - 21023			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	6	18	
AMPHIPODA			
Crangonyx	2		
Hyalella azteca			28
BASOMMATOPHORA			
Ancylidae	1		1
Menetus		1	
Physella		1	*
COLEOPTERA			
Dubiraphia	1	4	21
Ectopria nervosa	1		1
Helichus basalis			1
Helichus lithophilus			1
Macronychus glabratus			1
Microcylloepus pusillus	11		15
Optioservus sandersoni	1		
Psephenus herricki	27	2	1
Stenelmis	24	14	17
DECAPODA			
Faxonius luteus	1	*	1
DIPTERA			
Ablabesmyia		20	
Ceratopogoninae		2	
Cladotanytarsus		4	
Clinocera	1	2	
Corynoneura		7	10
Cricotopus/Orthocladius	13	6	6
Cryptochironomus		1	
Diptera		1	
Eukiefferiella	4	1	
Forcipomyiinae	1	1	

Gonomyia		1	
Hemerodromia	3	2	
Labrundinia		1	2
Microtendipes		1	
Muscidae		1	
Natarsia		3	
Nilotanypus		1	
Ormosia		2	
Orthocladius (Euorthocladius)	2		
Paralauterborniella		1	
Paratanytarsus	1		5
Polypedilum flavum	11		
Polypedilum laetum		1	
Polypedilum scalaenum grp	3	4	3
Prosimulium	2		
Psectrocladius			1
Rheocricotopus	1		3
Rheotanytarsus	2	1	15
Simulium	111		20
Stempellinella	5	36	8
Stenochironomus	1		
Stictochironomus		9	
Tabanus	*		
Tanytarsus	5	26	8
Thienemannimyia grp	4	14	3
Tipula	2		*
EPHEMEROPTERA			
Acentrella	52		8
Baetis	17		2
Caenis latipennis	53	88	27
Eurylophella bicolor			1
Eurylophella enoensis			5
Isonychia bicolor	2		
Leptophlebiidae		1	
Plauditus	21		12
Stenacron	3	2	1
Stenonema femoratum		1	
Stenonema pulchellum	24		
Stenonema terminatum	17	1	
Tricorythodes	30	6	52
HEMIPTERA			

Microvelia			1
ISOPODA			
Caecidotea		16	35
Lirceus	1		
LUMBRICINA			
Lumbricina	*		
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	37	14	73
ODONATA			
Boyeria			1
Calopteryx			5
Enallagma			6
Gomphidae	10		
Hagenius brevistylus	*		*
Hetaerina			3
Stylogomphus sigmastylus	*		
PLECOPTERA			
Acroneuria	*		*
Amphinemura	10		
Isoperla	9		
Perlesta	25		23
Perlinella ephyre	1		
TRICHOPTERA			
Agapetus	1		
Cheumatopsyche	1		
Chimarra	1		
Helicopsyche	17	1	1
Hydroptila	1		1
Micrasema			2
Mystacides		4	1
Nectopsyche			1
Neophylax	*		
Oecetis		1	2
Pycnopsyche		*	*
Rhyacophila	2	1	*
Triaenodes			16
TRICLADIDA			
Planariidae	8		
TUBIFICIDA			
Branchiura sowerbyi		1	
Tubificinae		3	
VENEROIDA			
Pisidiidae	1	2	

Appendix B

Ozark/Apple/Joachim EDU Wadeable/Perennial Biological Criteria Reference Stream

Biological Metrics Values

Fall BIOREF Stream Metric Values for the Ozark/Apple/Joachim EDU					
Stream	Date	TR	EPTT	BI	SI
Apple Creek	9/19/2012	81	23	6.3	2.73
Apple Creek	9/29/2011	81	20	6.7	2.31
Apple Creek	9/19/2000	81	24	6.4	3.11
River Aux Vases	9/19/2012	68	17	6	2.85
River Aux Vases	9/26/2011	85	21	6.1	3.04
River Aux Vases	9/18/2000	79	20	5.9	2.4
Saline Creek	9/19/2012	86	21	6.3	3.18
Saline Creek	9/26/2011	92	23	6.3	3.33
Saline Creek	9/22/1999	92	20	5.9	3.29
Saline Creek	9/18/2000	81	24	5.8	2.86
Spring BIOREF Stream Metric Values for the Ozark/Apple/Joachim EDU					
Stream	Date	TR	EPTT	BI	SI
Apple Creek	3/14/2000	88	21	6.8	3.32
Apple Creek	3/21/2001	89	16	6.6	3.01
Apple Creek	3/20/2012	104	22	6.4	3.35
Apple Creek	3/26/2013	77	16	6.7	2.57
River Aux Vases	3/15/2000	100	22	6.2	3.33
River Aux Vases	3/15/2000	99	24	6.1	3.36
River Aux Vases	3/21/2001	104	25	6.1	3.12
River Aux Vases	3/27/2012	103	22	5.8	3.56
River Aux Vases	3/27/2012	106	27	5.9	3.49
River Aux Vases	3/26/2013	96	24	5.9	3.31
Saline Creek	3/26/2013	103	22	6.1	3.6
Saline Creek	3/18/1999	85	21	5.9	2.63
Saline Creek	3/15/2000	100	28	6	3.63
Saline Creek	3/27/2012	103	24	6.3	3.61

TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index.